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# Paper Session II-A - 25 Aerospace Cost Factors

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**Title:**

# 25 Aerospace Cost Factors
# or
# 25 Aerospace Cost Factors for Facilities, GSE, and O&M
# or
# 13 New Ways to Reduce Aerospace Cost Factors

**by**

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## Abstract/Introduction

**What are the 25 cost factors for aerospace facilities, Ground Support Equipment (GSE), and Operations and Maintenance (O&M)? Which of these factors are built in the estimate? Which factors are separate add-ons, which factors are site specific, such as, LC39 Processing and Assembly Facility, Launch Pads? What two new concepts offer the greatest hope for reducing costs? Seventeen of these Aerospace Cost Factors also apply to GSE. What is the Special Aerospace Construction? Many of these special cost factors also apply to computer facilities, electronics, process industry, nuclear energy, internet, intranet, and satellite communications. Some Rule of Thumb (ROT) costs are also included. What are the thirteen ways to reduce cost factors? What are the 3 major aerospace cost factors? What are some of KSC's GSE estimating tools used to help reduce these over 25 higher cost factors? What are some of KSC's GSE estimating tools used to help reduce these over 25 higher cost factors?**

**Key Words – Aerospace Cost Factors, 25 Cost Factors, Ground Support Equipment (GSE), Operations and Maintenance (O&M) costs, 17 GSE Factors, Clean Rooms, $GN_2$ Explosion Proof, EMI Shielding, Fiber Optics, HEPA Filters, Special Conditions, EELV, Ocean Launch Pads, Aerospace Cost Reductions, Class 100, Fondu Fyre Concrete, P.T.& I.**

**Rates, Sound Suppression, Wet Lands, S Band, PACAS, Access Floor, Hypergol/Cryogenic, Activation.**

# Aerospace Cost Factors

## Background

**As a successful, retired NASA/KSC Lead Cost Engineer, This and my previous papers document my over 80 tools and spin-offs and their usefulness to estimators and contractors, as well as local, state, and Federal Government organizations. These tools have been and are being used throughout the USA by the Air Force, US Navy, US Coast Guard, and other NASA field centers, over 30 architects and engineer firms, and over 1,000 individuals. Their usefulness has been documented by almost 1,000 responses to NASA Technical Briefs from 1983 to 1995 and, based on personal feedback, telephone conversations, letters, and comments, over 40 published and or presented professional technical papers to over 800 professionals on aerospace government estimating.**

### Aerospace Construction and GSE Introduction

**Aerospace Construction and GSE may cost from 5 to 30% more than industrial and commercial construction because of many unique requirements, such as, Safety & Reliability in receiving, checking out a launching vehicle, and payloads in space. The systems involve hazardous material, fluids, and gases, electrical, electronic, and high pressures. The following list of over 25 significant cost factors with special notes of Ground Support Equipment (GSE) (17 Items). Some of these factors may increase cost by 30 to 200%, such as, Class 100 laminar flow clean rooms, remote control high pressure panel, extensible platforms, double wall stainless steel piping systems with sensors, and steel shielded buildings – _" welded plate.**

**These aerospace cost factors were first presented at the First World Cost Engineering and Project Management Congress, July 1992, as KSC Significant Cost Factors, as part of the technical paper, "Aerospace Construction Cost Estimating" by KSC – DFFED Lead Cost Engineer. However, they have been expanded as the result of seminar students' questions and recent efforts by the aerospace industry for better, faster, and cheaper goals. Many of these cost reduction items have been documented in "JAB's Nine Volumes of Seminar Workbooks."**

# KSC GSE Estimating Tools

**What are some of the KSC cost estimating tools developed by KSC Lead Cost Engineer that are helping reduce the over 25 Aerospace Cost Factors?**

- **KSC Estimating Specifications (2)**
  - **G-0002 Construction**
  - **G-0003 Ground Support Equipment Fabrication**
- **KSC Monthly Cost Indexes – 1974 – 1999, & Excel Escalation Charts**
- **Aerospace Price Books – 5 Volumes**

- **Abstract of Bid Costs (with Comments and COC)**
- **Government Estimates of Previous Projects in EDC (PRC – WO)**
- **Jim Hart's GSE Reports – Over 100 pages of GSE Buys for Shuttle & Space Station (2 reports)**
- **GSE References – Over 60**
- **Existing GSE to Evaluate, Compare, See it, Feel it, and Weigh it**
- **JAB's Aerospace Cost Engineering Seminar Workbooks – 8 Volumes**
- **12 Excel Templates & For GSE Cost Estimates**
- **Abstract of Construction & GSE Bid Cost over $1 Billion**
- **GSE System Summaries, Budget, Labor & Material, GSE Cost Control Process, etc. (4)**
- **CD ROM #1, #2, and #3 – KSC Historical Cost Data & Sensitive Cost Data, etc.**

# 25/17 Significant KSC Cost Factors

**Design – Higher Cost, 5-30% on Normal Aerospace Construction, however, 30% - 200% on Special Construction & GSE**

| | **Facilities** | **GSE** |
|---|---|---|
| **a.** | **Wind Loading – Hurricane (Built-in to Design) This is increasing since recent hurricanes.** | |
| **b.** | **Corrosion Protection – Sand Blast/Zinc (may be built-in to steel material cost)** | **(1)** |
| **c.** | **Tolerance Assembly Fabrication (Bolts?) (Built-in)** | **(2)** |
| **d.** | **Inspections, Quality Control (Built-in)** | **(3)** |
| **e.** | **Reliability – Redundancy (Built-in)** | |
| **f.** | **Special Construction – Access Flooring; Mechanical Systems, S.S. Pipe, ECS Duct,Welding, Halon, GSE, High Pressure Panels, Vacuum Jacket; Hypergol/Cryogenic, Cranes, Brakes, Controls (Special Add-ons) (Built-in)** | **(4)** |
| **g.** | **Electrical – Bonding and Grounding (Built-in) Special Lightning Protection** | **(5)** |
| | **Emergency Power (Add-on)** | |
| | **Uninterruptable Power (Add-on)** | **(6)** |
| | **$GN_2$ – Explosion Proof (Built-in) (Some Add-ons)** | **(7)** |
| **h.** | **Communications; Audio, Video, Data, P.A., etc. ($6-$10/SF) (Separate Add-on)** | |
| | **Fiber Optic Cable, Premis Wiring for Computers, networking, videos, data, etc.** | **(8)** |
| **i.** | **Environment – Wet Lands, Toxic Disposal Permitting (Built-in or added cost)** | **(9)** |
| **j.** | **Security – EMI – Steel Shield, NRP PACAS (Add-on) (Built-in)** | |
| **k.** | **Fire Protection/Detection, Halon, $10-20/SF, Deluge, U-VIR** | |
| **l.** | **Clean Room, Conventional and Laminel Flow – Class, HEPA Filters $200/SF** | **(10)** |
| **m.** | **UCS – Electrical, Sensors** | |
| **n.** | **Acid Disposition – Epoxy, Polyurethane Coating (Built-in) Hazardous Operations** | |
| | **- May require special downtime, weekly meetings, etc.** | |
| **o.** | **Hazardous Operations – May require special downtime, weekly meetings, etc.** | **(11)** |
| **p.** | **Lines of Site – S Band? (Built-in)** | |
| **q.** | **KSC Productivity – Specialized – Aerospace (-5% to + 60%)** | **(12)** |
| **r.** | **KSC Special Conditions – GFE, J.O.B.O., Downtown Acceleration, Badging, Safety, Escorts** | **(13)** |
| **s.** | **Weather extremes – Hot to Freezing – requires extra insulation, protection** | |

**t. Davis Bacon – Wage Rates and Productivity**
**u. Florida – Higher Payroll Taxes and Insurance – Workman's Compensation**
**v. Remote Location – 50 miles to Major Metropolitan Area, Airports, Labor Halls, Warehouses**
**w. Special Underground Utility Tunnels for High Pressure Gas, Fluids, Cable Trays, etc. (14)**
**x. Concrete Duct Banks for Power and Cabling, Underground and Above Ground (15)**
**y. Operation & Maintenance of Facilities & GSE Buildings Costing $15.50 - $30.00 (16) Per Square Foot per year (1.5 to 5 times commercial, industrial O&M costs), based on 5,612,066 SF(see Volume VI, "JAB's Aerospace Indexes and Cost Data," pg 174-A-F). Some special GSE doors may cost $20 - $25 million for repair and/or replacement as part of GSE O&M costs. The aerospace utilities, operations, and maintenance costs for life cycle cost analysis are documented in Volume VI, however, they were originally included in the Aerospace Price Books, Volume I. But later, they were deleted due to the sensitivity of this type of cost data.**
**z. Cost of design of aerospace facilities. This cost is higher because of unique, one of a kind facilities with special design requirements such as listed above. The design cost may average from 5% - 15% of construction cost.**
**aa. The cost of change orders due to the complexity of aerospace projects. One of a kind - never done before – some studies show average cost of 19 to 23.8%, with some projects up to 97%. Note: The 17 items noted also apply to Aerospace GSE items causing them to cost more than Normal Ground Support Equipment used in private and public industry.**

# Three Major Additional Cost Factors

1. **<u>Ground Support Equipment (GSE):</u> This cost depends on the requirements. It may cost 2 times the construction cost – example SSPF. Facility construction cost $70 Million and GSE cost near $140 million (as of 10/24/99). Note "JAB's Aerospace Government & Contractors' Estimating"); Volume V lists over $718 million of GSE for Shuttle and Space Station.**

2. **The cost of <u>Design of GSE:</u> This costs more than normal building design costs. GSE design cost may average 10% to 50% of GSE cost. However, it may vary from 2% to 90% of GSE cost on smaller, unique equipment.**

3. **The cost of <u>Activation</u> depends on the requirements, and amount of GSE in the project. The cost of activation includes the cost of installation of GSE, test, terminations, and verification of GSE and other costs involved in getting the facility ready for processing launch vehicles, payloads, or space station elements, etc. The cost of activation may be as little as 5% of facility cost or up to the cost of GSE. However, the total of GSE, Design, and Activation on new mods or projects may be up to 5 times the construction cost, so the $70 million SSPF, Construction cost times 5 = $350 million project cost. The SSPF was budgeted for $380 million as noted in the NASA Technical Paper, "Estimating Analysis & Bidding Strategy of Space Station Facility using KSC Aerospace Spin-Off Tools" (6/28/96). This is a very small part of the space station's estimated cost of $60 billion. The aerospace**

**project cost equals the cost of design, construction, S&A and activation, with GSE,**

**installation, testing, termination, verification, and acceptance.**

**Another way to show this for Aerospace Project Cost (APC).**

**APC = Design + Construction + S&A + Change Orders + Activation.**
**Activation = Design of GSE + GSE + Installation + Testing + Termination + Verification + Acceptance.**

# 13 Aerospace Cost Reduction Factors

1. **An example of Facilities & GSE Cost Reduction is the Clean Pad Concept. The Ship & Shoot, using liquid propellants. No towers needed, no lightning protection, no cranes, no extra weather protection, no $GN_2$ explosion proof systems and components needed (see pages 62-65, Volume V of "JAB's Aerospace, Government, and Contractors' Estimating," for graphic presentation.)**

2. **Another GSE cost reduction is the use of an Ocean Launch Platform or Sea Launch as shown on the cover of *Launch Space* May/June 1999 (the magazine of the space industry). Some background: In the mid-1960s, the Air Force, Department of Defense, began studying sea launches such as might be launched from an oil or radar ocean type platform off Cape Canaveral. A request was made to NASA for a quick Rough Order of Magnitude (ROM); the 1967 answer was two to ten million dollars. In 1988, a Brown & Root Technical Paper was presented to the 25th Space Congress with details and cost savings, and technical feasibility with limited launch crews of 100-200 for a Gulf or Ocean platform, "probably less than one-half the cost of providing new, fixed, onshore launch facilities." In the 90s, Boeing's concept was successful with a 5400-KG (1200 pounds) dummy payload March 27, 1999, using a Zenith 3SL rocket. The first commercial satellite's successful launch was October 9, 1999. It was a 7,600-pound U.S. Direct TV satellite. The self-propelled launch pad, accompanied by a support ship, is a former oil-drilling platform. The satellite reached orbit 62 minutes after liftoff. This concept, using a Sea Launch ship, holds up to 240 launch team members. Some of the cost reductions for this concept are:**

   - **No down range tracking facilities needed, can be tracked by satellite**
   - **Reduced Government paperwork, rules, and policies**
   - **Time saving – reduced downtime for other launches**
   - **Reduced personnel for operations and launching**
   - **Reduced air traffic for remote ocean launch platform**
   - **Better payload lift near equator**

3. **Other cost reduction factors: The use of <u>Fiber Optics Cable</u> for instrumentation and communication as noted in Joe A. Brown's "12 New Exciting Estimating Tools" technical paper.**

   **A new, faster, and more accurate way to estimate cost by using the fiber feet or fiber meter as a unit quantity for estimating or an average of 0.17 per fiber foot. See Average Cost Summary Chart.**

# Average Cost Summary Chart

| FM Average Cost | By Fiber Meter | Size of Project | By Fiber Foot | FF Avg. Cost |
|---|---|---|---|---|
| .96 | .72 – 1.53/fm | Small<br>Less than<br>500,000 M | .30-45/FF | .34 |
| .67 | .61 - .72 | Medium<br>.6 to 1.5 Million M | .19 – 22 | .205 |
| .46 | .36 – 47 | Large | .11 – 15.5 | .13 |

**Overall Average - .688/FM .17/FF**

**Fiber Optics cable is cheaper than the copper cables systems used for Communication & Instrumentation at KSC from 1960 through the 1980s.**

3. **Another cost reduction factor is the use of Space Age Satellite Dish for cheaper communications and data transmission. As shown in the low bidder video "How Does the Successful Low Bidder Get Low and Make Money," where Metric Construction was the low bidder on the Space Station Processing Facility's (SSPF) $56 million bid. A small satellite dish was used at the construction site to reduce long line communication costs to the home office, etc. The SSPF project was successfully completed months early.**

**Summary:**

**Some of the cost reductions of Aerospace Cost Factors are:**

1. **Clean Pad Concept-Venture Star, also Florida and California Spaceports**
2. **Ocean Launch Platforms (Orders for 19 more launches)**
3. **Use of Fiber Optics Cables**

**Computerization**

4. **CAD/Design of Facilities & GSE**
5. **Plan & Scheduling of Facilities, GSE, O&M**
6. **Estimating of Facilities, GSE, O&M**
7. **Cost Data – CD-ROM – Historical & Sensitive Data**
8. **Cost Accounting, Records Keeping, Time Cards**
9. **Satellite Communications**
10. **Internet Communications**

11. **Types of Contracts – Incentive Fee, Joint Operations Contracts between other agencies, Combination Contracts of Support and Sub-Contractor teams**
12. **Design Contracts – with Incentive, Design to Cost Limits**
13. **Change Order Costs – These are being reduced by total cost management team efforts, education, and incentives – recently to 8% of bid prices on GSE projects.**

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